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The Institution as a body is not responsible for the statements of opinion expressed in any of its publications.

Copyright.—Publication of abstracts of Papers and articles appearing in the Journal is permitted, provided that acknowledgment is made to the Institution of Petroleum Technologists.

Papers and Articles.—The Council invites Papers and Articles both for reading at Ordinary Meetings of the Institution and for publication in the Journal. All Papers, whether for reading or publication, will be submitted to a referee appointed by the Publication Committee.

The Institution has published a brochure "Instructions for the Guidance of Authors" containing details of recommended practice in the preparation of Papers for publication. Copies of this brochure will be supplied on request.

Pre-Prints.—Advance proofs of Papers to be read at Ordinary Meetings are generally available about a week before the Meeting. Members wishing to be supplied with these pre-prints are requested to notify the Secretary.

Abstracts.—Members and Journal Subscribers desirous of receiving the Abstracts printed on one side of the paper only, can be supplied with these at a charge of 10*s.* per annum per copy, payable in advance.

Issue of Journal.—Members whose subscription is not in arrear receive the Journal free of cost. A member whose subscription is not paid by March 31st of the year for which it is due is considered to be in arrear.

Changes of Address.—Members are requested to notify any change of address to the Secretary.

Benevolent Fund.—The Benevolent Fund is intended to aid necessitous persons who are or have been members of the Institution, and their dependent relatives.

The Fund is raised by voluntary annual subscriptions, donations, and bequests, and all contributions should be sent to the Secretary of the Institution at Aldine House, Bedford Street, London, W.C. 2. The Fund is administered by the Council through the Benevolent Fund Committee, and all applications in connection therewith must be made on a special form which can be obtained from the Secretary of the Institution.

Appointments Register.—A register of members requiring appointments is kept at the offices of the Institution, and every effort is made to assist members of the Institution in search of employment.

Members who desire their names and qualifications to be included in this register are requested to apply to the Secretary for the Form of Application for Registration, if they have not already done so. Members residing in the London area are asked, if possible, to return this Form in person and make themselves known, together with their requirements, to the Secretary. It is also requested that members should notify the Secretary immediately they have obtained an appointment.

In submitting names of candidates to prospective employers it is understood that the Institution accepts no responsibility and gives no guarantee.

Library.—The Institution's Library may be consulted between the hours of 9.30 a.m. and 5 p.m. daily. (Saturdays, 9.30 a.m. to 12 noon.)

NEW MEMBERS.

The following have been elected or transferred, subject to confirmation in accordance with By-Laws, Sect. IV, paras. 14–15, since the last issue of the *Journal*.

Members.

Begg, Alfred John	Manchester.
Borwick, Henry Barton	Australia.
Demoulins, Henry Dieudonne	Fawley.
Fenske, Merrell Roberts	Pennsylvania.
Herring, Percy Henry	East Molesey.
Holley, Alfred Ewart	Skewen.
Lamb, Maurice Frederic	New Zealand.
Mackie, William Frederick Charles	Mexico.
Malherbe, Gideon John	New York.
Swanson, Harry Robert	New York.
Thornbury, William Madison	Mosul.
Tillmann, Richard	The Hague.

Associate Members.

Edwards, Stanley Haines...	New Zealand.
Gardiner, Russell Doverdale Campbell	Montreal.
Hearn, Harold Edwin	Trinidad.
Potter, Joseph Peach	Trinidad.
Schneider, Frederick John	Hull.
Sundstrom, Richard Fleming	Stockholm.

Transfer to Associate Members.

Blackwell, William	Birmingham.
Darley, Henry Cecil Hastings	Trinidad.
Leendertse, Jacob Jan	Delft.
Perks, Angus John	Kirkuk.
Sweetland, Leslie Benjamin	Curacao.
Woolgar, Cedric Warren	Birmingham.

Students.

Hazzard, Geoffrey Francis	London.
Parr, Ronald Walter	Teddington.
Priestley, Samuel Albert Gaston	Australia.
Slade, Henry Martin	London.

Associates.

Buckeridge, Bernard Charles Jackson	Singapore.
White, Reginald Christopher	Ilford.

NOMINATIONS FOR MEMBERSHIP.

The following nominations for membership of the Institution of Petroleum Technologists were approved by the Council on 10th December, 1935, and the Application Forms may be seen at the office of the Institution.

The names of Proposer and Seconder are given in parentheses.

As Members.

BENNION, John Edward, Manager, Shell-Mex & B.P. Ltd., Sunlight House, Quay Street, Manchester. (J. Kewley; A. E. Dunstan.)

BRAILEANU, Ion G., Engineer, Astra Romana, Boldesti, Prahova, Rumania. (J. L. Chaillet; J. E. Treacy.)

COX, Percy Thomas, Geologist, c/o Anglo-Iranian Oil Co., Ltd., Britannic House, Finsbury Circus, E.C. 2. (E. C. Brewster; H. S. Gibson.)

GODFREY, William Edgar, Manager, Research Station, c/o Anglo-Iranian Oil Co., Ltd., P.O. Box No. 1, Chertsey Road, Sunbury-on-Thames, Middlesex. (A. E. Dunstan; F. B. Thole.)

LESLIE, Robert Wilson, Director of Research & Development Dept., c/o Skelly Oil Company, El Dorado, Kansas, U.S.A. (C. K. Francis; J. T. Hayward.)

As Associate Members.

DEAN, Cecil Percy, Production Assistant, c/o Cia Petrolera Lobitos, Lobitos, Peru, South America. (J. Henry; G. E. Owles.)

SEFTON, Ronald, Chemist, 42, Cephas Street, Mile End, E. 1. (J. Kewley; W. B. Heaton.)

As Transfer to Associate Members.

HOBLEY, Charles Edward, Geologist, c/o Caribbean Petroleum Co., Maracaibo, Venezuela, South America. (G. S. Taitt; W. G. C. Tomalin.)

LINDSAY, John Alexander, Engineer, 1, London Wall Buildings, E.C. 2. (W. B. Heaton; R. Beaumont.)

SANGSTER, Eric Bruce, Student, 61, Selly Park Road, Selly Park, Birmingham. (A. W. Nash; L. V. W. Clark.)

As Students.

BROWN, Guido Waldo Herbert, Cracking Plant Operator, c/o Trinidad Leaseholds, Ltd., Pointe-a-Pierre, Trinidad. (B. G. Banks; J. T. T. Robinson.)

DE NIE, Willem Leendert Johannes, Assistant, Petroleum Dept., van Leeuwenhoeksingel 24, Delft, Holland. (H. I. Waterman; W. J. Hessels.)

HOLBROOK, Edward Morison, Student, The Rosery, 109, Oakfield Road, Selly Park, Birmingham. (A. W. Nash; L. V. W. Clark.)

JENNINGS, William Munro, Jr. Student, 21, Marksbury Avenue, Richmond, Surrey. (S. Bowrey; P. Driver.)

MOORE, Philip Harold, Student, Chancellor's Hall, Augustus Road, Edgbaston, Birmingham. (A. W. Nash; L. V. W. Clark.)

NISSAN, Alfred Heakel, Student, 200, Lichfield Road, Birmingham, 6. (A. W. Nash; L. V. W. Clark.)

THI, Maung Ba, Student, The University, Edgbaston, Birmingham. (A. W. Nash; L. V. W. Clark.)

VERDONK, Gijsbert, Student, Piet Heinstraat 38/40, Delft, Holland. (H. I. Waterman; J. B. Nieman.)

DE VERTEUIL, Louis Rene, Student, c/o Apex (Trinidad) Oilfields, Ltd., Siparia P.O., Trinidad. (G. H. Scott; A. H. Richard.)

APPLICATION FORMS FOR ADMISSION.

The Council desire to direct the attention of members who Propose or Second an Application Form for admission to the Institution to the importance of sending a covering letter for the guidance of the Election Committee.

ASSOCIATED STUDENTS.

In order to enable junior employees of petroleum companies to participate in the activities of the Students' Section of the Institution, the Council has approved "Associated Students" of this Section.

Associated Students will be entitled to receive notices of and to attend meetings of the Students' Section, and to make use of the Institution Library. They will not receive the *Journal*, and will not be eligible for Students' Prizes.

The subscription of an Associated Student is 7*s*. 6*d*. per annum, which should be paid to the Honorary Secretary, Students' Section (London Branch), Mr. B. C. Ferguson, St. Helens Court, Great St. Helens, London, E.C. 3.

There is at present no age limit for Associated Students, but they will be required to proceed to Student or other grade of Membership (according to age) before the expiry of two years from the date of their becoming Associated Students.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that members send information regarding their movements to the Secretary for insertion under this heading.

Mr. William Calder is home from Canada.

Mr. A. E. Chrisman is home from India.

Mr. W. E. D. Cole has returned to Iraq.

Mr. R. N. Kirby has left Trinidad and is now in Bahrein Island.

Mr. I. McCallum is home from Trinidad.

Mr. R. E. de Mestre has left for Iraq.

Mr. N. Pachachi is in Iraq.

Mr. R. Panisset is home from Mexico.

Mr. M. J. Robertson has returned to Uganda.

Mr. M. A. Rust is home from Trinidad.

Mr. G. E. Stott has left for Uganda.

Mr. E. R. Ward is now in Burma.

The Secretary would be glad to learn of the addresses of the following Members :—A. MacLean, W. W. Pearce, and K. A. Spearing.

STUDENTS' MEDAL AND PRIZE.

The Council has awarded the Students' Medal and Prize to Mr. H. T. Lorne, B.Sc., A.R.C.S., for his Paper on "The Adsorbent Action of Certain Natural and Treated Earths upon Bitumen and its Constituents."

Mr. Lorne, a former Student of the Royal School of Mines, was elected a Student of the Institution in January 1935.

STUDENTS' PRIZE PRESENTED BY MR. T. C. J. BURGESS.

The first award of the Students' Prize presented by Mr. T. C. J. Burgess has been made to Mr. B. O. Lisle for his Paper on "The History and Development of the Tankship."

Mr. Lisle was elected a Student of the Institution in 1934.

WORLD PETROLEUM CONGRESS.

The audited Statement of Accounts of the World Petroleum Congress held in July 1935, together with the Report of the Council, are printed on pp. 1015–1018 of the present issue of the *Journal*.

The Council has accepted the invitation of the Association Française des Techniciens du Pétrole to hold the next Congress in Paris in June or July 1937.

FORTHCOMING MEETINGS.

There will be no meeting of the Institution in London in January 1936.

The January meeting of the Institution will be held in Manchester on January 17th or 24th, 1936.

Full particulars of the meeting will be circulated at the beginning of January to all members of the Institution having a registered address in the United Kingdom.

SYMPOSIUM ON WELDING.

On Tuesday, February 11th, 1936, the following Papers on "Welding in the Petroleum Industry" will be presented for discussion:

Welding in Field and Drilling Equipment, by J. Cuthill, A.M.Inst.P.T.

Welding in the Transportation and Storage of Petroleum Products, by A. C. Hartley, M.Inst.C.E., M.I.Mech.E., M.Inst.P.T.

Welding of Pressure Vessels, by Eng. Lt.-Comm. S. F. Dorey, R.N., D.Sc., M.I.Mech.E.

The Training of Welders.

The meeting will be held at the Royal Society of Arts, John Street, Adelphi, W.C. 2. Particulars of the time of the meeting and advance copies of the Papers will be published at a later date.

MEETING IN HOLLAND.

Preliminary Announcement.

Arrangements are being made in collaboration with the Royal Dutch Institution of Engineers, for a meeting of the Institution in Holland on May 8th–12th, 1936.

Technical Sessions will be held at The Hague and Amsterdam, at which Papers on Diesel Fuels and Diesel Engineering will be presented. The programme will include a series of visits to works and other places of interest.

It is anticipated that the inclusive cost of the visit from London will be about £12. A special circular giving details of the meeting will be circulated to all members of the Institution in February 1936.

Overseas members who are likely to be visiting Europe in May 1936 are asked to make a note of the above dates.

ARTHUR W. EASTLAKE,
Honorary Secretary.

BACK NUMBERS OF JOURNAL.

The Institution is desirous of purchasing a limited number of clean copies of Journal No. 19, April 1919.

The price which will be paid for such copies is 7*s*. 6*d*., and all enquiries should be sent to the Secretary.

CONTENTS OF JANUARY JOURNAL.

The following papers are scheduled for inclusion in the January issue of the *Journal*:

"Redwood-Kinematic Relationship at 70° F., 140° F., and 200° F." F. H. GARNER, W. E. J. BROOM and J. L. TAYLOR.

"Report on Relation between Redwood Seconds and Kinematic Viscosities." National Physical Laboratory.

"Drainage Errors in U-Tube Viscometers." W. E. J. BROOM.

"Suspended Level Viscometer." L. UBBELOHDE.

"Accuracy of Engler Viscometers." F. H. GARNER and W. E. J. BROOM.

"The Ball and Bucket Viscometer." E. S. L. BEALE and P. DOCKSEY.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE One hundred and Sixty-seventh General Meeting of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, November 12th, 1935. The Chair was taken by the President, Sir John Cadman.

In connection with this meeting, an exhibition of testing apparatus and other items of interest was arranged. The exhibitors and the exhibits were as follows :—

Anglo-Iranian Oil Co.—Limestone cores, rock specimens, fossils, and microscope slides of rock sections from the oil-fields of Iran.

British Laboratory Ware Association.—Standard apparatus for the testing of petroleum products in accordance with the specifications of the Institution's Standardization Committee.

Duke and Ockenden, Ltd.—A demonstration model of the Zublin drilling bit and the heads used for drilling in various formations and for side-tracking and milling.

A sample of the crude oil obtained from a depth of 3070 feet in the well at Hardstoft, Derbyshire.

George Kent, Ltd.—A variable velocity ratio device for varying the speed ratio of two spindles, with an infinitely variable ratio within an approximate limit of 10 per cent.

A recording pressure controller with a self-contained opposed-nozzle valve unit and built-in supply and diaphragm pressure gauges.

J. Kewley.—A lump of asphalt which was found embedded in the flood layer at Ur of the Chaldees. A detailed description will appear in a later issue of the Journal.

Moore and George, Ltd.—A laboratory vacuum distillation unit and apparatus for seven-stage counter-current treatment (see pp. 993–994).

Ullage rules used in the measurement of the oil content of tanks.

Reed Roller Bit Co.—Models of modern rotary drilling tools, including bits, reamers, guides, Barrett-Robishaw combination drilling and coring tool, collapsible blade bit, and wire-wrapped screen.

Shell Laboratories.—Laboratory testing apparatus, including the Harris lamp for inspecting the inside of cans, a device for quartering samples of solid materials, Fraas breaking-point apparatus, a penetrometer for determining the thickness of coats of paint, the Saal sinker viscometer, a sample of *iso*-octane, and plant for the manufacture of grease on a small scale.

A length of line pipe was exhibited which, in successive sections, illustrated the measures taken to prevent corrosion by first pickling the pipe in phosphoric acid, then applying several coats of paint or

enamel, wrapping with bitumen-impregnated coir and finally coating with a layer of asphaltic bitumen.

During the evening a series of short papers were presented by their authors :—

"The Ball and Bucket Viscometer." E. S. L. Beale and P. Docksey. (To be published in January.)

"A Test for the Water-Resisting Properties of Paints for Steelwork." L. P. McHatton. (See pp. 989–992.)

"Laboratory Vacuum Distillation Unit and Laboratory Seven-Stage Counter-Current Treating Apparatus." Harold Moore. (See pp. 993–994.)

"An Examination of Some Quenching Liquids." N. E. Wood. (See pp. 995–999.)

A TEST FOR THE WATER-RESISTING PROPERTIES OF PAINTS FOR STEELWORK.

By L. P. McHatton.

Owing to the difficulty of predicting with any degree of certainty the behaviour of paint films when exposed to varying atmospheric conditions, a certain number of laboratory tests have been developed with a view to obtaining an approximate idea of the merits of various types of paints in this respect.

Electrical methods have been suggested, and Digby and Patterson have described the results of their experiments (*Engineer*, June 15th, 1934). Their method consists of coating a metal sheet (about 8 sq. ft. in area) with the paint to be tested, and making this one of the poles of a voltaic cell, the other electrode being a pair of graphite plates. For the electrolyte of the cell was chosen any conducting liquid to which the paint might be exposed in practice, *i.e.* tap- or sea-water, acids, alkalis, etc. The authors claim that the breakdown in the paint film is proportional to the e.m.f. developed between the electrodes. Some paints they examined showed signs of failure after 24 hours, a reading of 10 millivolts being obtained in such cases, whilst others showed no appreciable change after 7 or 8 days' immersion. None of their samples, however, survived after 14 days' contact.

They found that short-circuiting the electrodes was necessary to give an effective test of short duration, and the test was therefore carried out by connecting the two electrodes by an external conductor. Before a reading for e.m.f. was made, the cell was open-circuited for 15 minutes. Observations were usually made once every 24 hours. It was also found that a current of air passed through the electrolyte reduced polarization effects and helped to give concordant results. A millivoltmeter was used for obtaining the e.m.f. reading.

Attempts were made to repeat the above experiments on a smaller scale, as it was considered that, if a more sensitive method was used for measuring e.m.f., similar results might be obtained on smaller exposed areas of paint. In these experiments, therefore, an electrometer valve potentiometer was used for measuring the voltages, as it is possible with this apparatus to measure with accuracy the e.m.f. of small-capacity cells with very high internal resistances. For the construction of the cell a rectangular glass vessel, open at one end, was chosen. A painted metallic plaque was clamped over this end, a rubber washer being interposed between the plaque and the rim of the glass vessel to protect the paint film from damage and to ensure a water-tight joint. A carbon electrode was inserted by drilling two holes centrally in the opposite sides of the rectangular vessel, the carbon rod being held in position by means of two rubber stoppers. To enable a current of air to be drawn through the cell, two holes were also drilled at the

top and bottom respectively of the other two sides of the vessel, and delivery and exit tubes were inserted by means of corks.

To carry out a test, the painted plaque was clamped into position, the whole apparatus inverted and sufficient electrolyte introduced to cover the carbon electrode. E.m.f. and resistance measurements, the latter by means of an Avometer, were made (*a*) initially and (*b*) after 24 hours. During this period the cell was short-circuited and left with a slow stream of air circulating through the cell. The following figures may be quoted as examples of the results obtained :—

Electrolyte :—Salt Water.

Type of paint used.	E.m.f. (mV).		Resistance (ohms).	
	Initial.	After 24 hours.	Initial.	After 24 hours.
Red lead/red oxide .	0	153	Over 1 megohm	1 megohm
Red lead . . .	46	199	1 megohm	10,000
White lead . . .	10	295	100,000	4,000
Synthetic resin . .	208	336	10,200	350
Cement glue . .	381	462	160	68

These results show that the e.m.f. increased as the resistance decreased, but the figures are not strictly proportional. Conclusions from the e.m.f. figures are further complicated by the fact that figures as high as 153 millivolts can be obtained (on the potentiometer) with a film having a resistance of 1 megohm, while in another case a film with a resistance of 10,000 ohms gave a reading of only 199 millivolts. It is therefore difficult to fix a definite e.m.f. which will indicate a breakdown. The rather low reading of 10 millivolts, taken by Digby and Patterson to indicate a definite failure, might have been due to the fact that in measuring the e.m.f. with a millivoltmeter, the latter discharges the cell at a higher rate than its capacity could provide, with a consequent fall in e.m.f.

To test this point a few e.m.f. readings were taken with the usual type of millivoltmeter of 500 ohms resistance in order to compare them with those obtained with the potentiometer. In the case of the red oxide paint giving a voltage of 153 mV. with the potentiometer after 24 hours, no reading was obtained with the millivoltmeter. The synthetic resin paint gave a reading of 5 mV.; whilst cement-glue, which is the most porous of the paints examined, as shown by the comparatively low resistance of the cell, gave a deflection of over 120 mV. on the millivoltmeter. Obviously, therefore, the e.m.f. readings depend largely on the type of apparatus used in the measurements, and in these experiments the fall in resistance was found to be a more reliable indication of any increase in porosity of the film.

In some cases it was noticed that the breakdown of the film was confined to a few isolated spots which indicated defects in application of the paint, such as the formation of pinholes, due possibly to air bubbles or to particles of dust, which would permit the electrolyte to diffuse between the metal and the paint film, and so cause a local breakdown.

In connection with the application of this test, it is suggested that it may

be possible to test paint films for such defects not visible to the naked eye, by the following simple method, which has been successfully used for the detection of pinholes in bituminous coatings.

The film to be tested is moistened with a solution of potassium iodide containing starch by laying over it a piece of muslin or filter paper saturated with the solution. The liquid penetrates to the metal through the pinholes, etc., and if the muslin is now connected to the negative pole of a small battery and the metal plaque to the other pole, the only path for current to pass is through the pinholes. Under these conditions, therefore, electrolysis occurs through these channels with the liberation of iodine at the negative pole, where it combines with the starch to produce the usual blue coloration. Absence of blue spots would indicate that the film was free from pinholes, and therefore fit for use in the electrical test.

As a fall in resistance of a film indicates an increase in porosity, the figures obtained should be proportional to its weathering properties. As such information would be valuable in the case of varnish vehicles in paint manufacture, a few comparisons were made. The results obtained indicated that boiled linseed oil and blends containing it showed a fall in resistance, and hence an increase in porosity. The addition of tung oil (about 30 per cent.) to such blends produced a definite beneficial effect. Copal varnish either alone or blended with tung oil showed no breakdown, and the use of these materials in vehicles for paints should produce improved water-resisting properties. These conclusions are indicated by the following figures, obtained by exposure to tap-water :—

	Resistance (ohms).	
	Initial.	After 96 hours.
Boiled linseed oil	25,000	1,750
„ „ containing 30 per cent. tung oil .	50,000	12,500
Copal varnish	500,000	500,000
„ „ plus 30 per cent. tung oil . .	100,000	100,000

The results indicate, therefore, that differences can be detected in the properties of paint films by the use of electrical methods, either the e.m.f. method of Digby and Patterson with large painted areas, or the resistance method outlined above, in which more convenient sized plaques can be used.

Up to the present little correlation between the laboratory tests and the results of actual experience has been possible.

DISCUSSION.

Dr. F. B. Thole asked the author whether the same reactions were obtained if the metal underneath the paper film had already been prepared as regarded its surface, say, by phosphoric acid, and whether any film of phosphate or anodic oxidation, or anything similar, would stop the reactions.

Mr. L. P. McHatton replied that he had not had any experience in that direction.

Mr. E. S. L. Beale asked what was the proportion of the current which went through the unbroken film and what proportion went through the pinholes, because the pinholes might be carrying the major part of the current. With regard to the use of different voltages for films having different resistances, was it not probable that in the measured value of the resistance the same film would be quite different when using different voltages by which to measure it?

Mr. L. P. McHatton said, with regard to the second point, he was afraid that he could not help using the higher resistances because the meter he was using specified that. As to the first point, if he discovered pinholes the whole test was invalid, and he had to start again to prepare a better paint film.

LABORATORY VACUUM DISTILLATION UNIT AND LABORATORY SEVEN-STAGE COUNTER-CURRENT TREATING APPARATUS.

By Harold Moore.

Laboratory Vacuum Distillation Unit.—The apparatus exhibited is one of several similar stills used in refinery laboratories for rapid and accurate evaluation of petroleum crude oils.

By the adoption of standard dimensions for various portions of the unit, it is possible to employ various interchangeable sizes of fractionating column and still bottom, so that the degree of fractionation may be varied to suit a wide range of different requirements, whilst the volume of the crude-oil charge may also be varied to suit the particular purpose of the distillation.

The apparatus shown is fitted with a four-litre-capacity still bottom, to which is attached an 18-inch, packed, fractionating column. Experience has shown that the performance obtained with this equipment is closely in line with modern commercial practice. Where exceptionally efficient fractionation is desired, however, a 30-inch column is employed when "gaps" between gasoline and kerosine fractions of about 22° C. are obtainable.

The general construction of the apparatus will be readily apparent on examination. No jointing material has been employed in any part of the unit, all joints being ground metal to metal surfaces.

The fractionating column is surrounded by an electrical heater in order to supply heat to the column when distilling products of high boiling range. The amount of heat supplied to the column is controlled by means of a variable rheostat, so that the reflux ratio is indirectly controlled over a wide temperature range. An apparatus for controlling and measuring the rate of reflux is at the present moment being developed, and will shortly be incorporated in future models.

Laboratory Seven-Stage Counter-Current Treating Apparatus.—This was designed primarily for experiments in connection with solvent refining processes, but the plant may, however, be used for any laboratory process where exceptionally efficient mixing and separation are necessary.

The oil to be treated and the treating liquid are contained respectively in two small tanks on either side of the apparatus, and the liquids pass continuously through the plant counter currently, the methods employed for admixture and separation being somewhat novel.

The two liquids are mixed by means of a rotary pump, and it should be noted that after admixture the liquids pass through two distinct pump circuits. There is first of all a closed pump circuit, through which the two liquids may be passed any desired number of times before passing into the double-cone-shaped separating tank, and there is also a second circuit,

through which the liquids enter the separating tank tangentially and thus cause the contents of the tank to rotate, the purpose of this latter circuit being to assist separation of the liquids before passing on to the next treating stage.

The exact design which has been adopted can readily be seen from an examination of the apparatus on view, and it will be noted that, by the use of seven successive stages, extremely efficient treatments can be carried out in the laboratory.

DISCUSSION.

Mr. J. A. Oriel asked the author if he had found it necessary to form a very intimate emulsion in order to get good solvent extraction with chlorates and similar solvents.

Mr. H. Moore replied that he had found that there was a certain optimum effect; if the emulsion was too intimate the settling was very difficult indeed, and if the mixing was not very intimate the washing was very much reduced. Ordinary mixing-up and shaking were not good enough. In the circuit they went 30 times through a centrifugal pump, which was working against a back-pressure, and actually it would be seen that the back-pressure was controlled by flowing through a beam of a definite orifice, which built up a pressure which was used for the settling vessels. If a circuit were used which went once through a centrifugal pump, the effect of the solvent extraction was almost negligible; and it had been found in the earlier experiments that, with a four-stage effect, worse results were actually obtained than were got by shaking in a bottle. They were certainly very sensitive to the intimacy of the mixture. He did not like chlorate in the oil because that carried impure oil with the chlorates.

AN EXAMINATION OF SOME QUENCHING LIQUIDS.

By N. E. Wood.

The following paper presents a short account of some experiments that have been carried out with a view to comparing the efficiencies of various quenching media in order to select the most satisfactory.

The object of the heat treatment of steel is the production of definite known physical properties, such as hardness and toughness.

It is well known that the slow cooling of steel results in the formation of a comparatively soft structure. Rapid cooling prevents the formation of this type of structure, and, depending on the rate of cooling, other structures accompanied by hardening are formed and finally preserved more or less unchanged. The ultimate hardness of the steel is thus dependent on the rate of cooling, and in order to obtain maximum hardness, it is necessary to cool the steel as rapidly as possible to a temperature below which no further possible structural changes will occur.

When, however, the metal has lost its plastic nature, below about 400° C., too rapid cooling from that point will set up stresses resulting in cracking and warping. It is apparent, therefore, that a slow withdrawal of heat is necessary at this stage.

Various types of quenching materials have been and are being used, such as water, aqueous solutions of caustic soda, brine, fatty oils and mineral oils.

It was, therefore, of interest and importance to study the behaviour of straight mineral oils as quenching media.

In order to investigate the variations in the rates of cooling of steel test pieces immersed in various quenching liquids, the following experiments were carried out.

Apparatus.

The quenching bath consisted of a cylindrical copper pot of just over three litres capacity fitted with a removable lid. In the centre of the lid a 2-inch-diameter hole was cut, and a cage fitted under the hole, reaching down to about two-thirds the depth of the pot. The cage was constructed of four $\frac{1}{4}$-inch strips and tapered to $1\frac{1}{4}$ inch width, so that the test piece could rest at the bottom in a vertical position. The lid was also fitted with collars to hold a thermometer and a stirrer.

The steel test piece was $2\frac{1}{2}$ inches long and $\frac{3}{4}$ inch diameter, and to one end was fixed a steel tube $\frac{1}{4}$ inch diameter and 3 inches long. A clay rod ran through the steel tube and carried the wires of a thermocouple into the steel test piece. The thermocouple was connected to a galvanometer calibrated in terms of the temperatures concerned.

In carrying out the tests, the steel test piece was heated to just over 850° C. in a furnace (either gas-heated muffle or electrically-heated tube

furnace), withdrawn, and at a temperature of 850° C. it was plunged into the quenching pot, which had previously been filled with three litres of the liquid under examination.

The contents of the pot were agitated with the stirrer, and the moment when the temperature of the steel reached 800° C. was taken as the zero time, a series of stop-clocks being started at that instant. Observations of the time and of the temperature of the quenching bath were made when the readings of the galvanometer indicated test-piece temperatures of 700° C., 600° C., 400° C., 300° C. and 200° C.

All observations were confirmed.

In this way the various times of cooling to these temperatures were obtained, and graphs showing the rates of cooling were constructed.

A few of the results obtained are given in Table I.

TABLE I.

Test-piece temperature. ° C.	Time of cooling from 800° C. in seconds.			
	Oil A.	Oil B.	Oil C.	Water.
800	—	—	—	—
700	4·2	6·2	5·0	2·6
600	8·8	11·2	9·5	5·1
400	21·5	24·9	22·5	10·2
300	36·6	36·7	38·4	13·9
200	63·6	57·9	60	31·7

These and other results have yielded some interesting information. It was discovered that the various types of oil gave cooling curves of widely differing characteristics. These differences would have important effects on the final hardness and the stresses that are produced in the quenched steel.

Oil "A" is a proprietary quenching oil prepared specially for use as a quenching material for steel; Oil "B" is a fatty oil which has also been used extensively for this purpose; Oil "C" is a light spindle oil. The cooling curve for water is also shown.

It will be noticed that over the whole range water cools extremely rapidly, down to a temperature of 300° C., before any appreciable slowing of the rate is apparent.

The use of a water as a quenching liquid must therefore be restricted owing to its tendency to produce cracking and warping owing to the too rapid cooling below about 400° C.

Comparing the curves of the three oils, it will be observed that Oils "B" and "C" (fatty oil and light spindle oil) show a slower cooling rate in the quenching period 800–600° C. than does Oil "A." The cooling periods to 600° C. are respectively 11·2 seconds, 9·5 seconds and 8·8 seconds. On the other hand, these two oils show a faster cooling rate than Oil "A" over the final cooling period of 400–200° C., 33 seconds, 38 seconds and 42 seconds.

Therefore from these results it can be concluded that Oils "B" and "C" are decidedly less effective than Oil "A," in that they will not

produce the desired hardness, and that they will leave the steel in a condition of greater stress.

Some other factors affecting the choice of an ideal quenching oil may perhaps be briefly considered.

The viscosity of the quenching oil plays an important part. Heat is transferred from the hot steel to the oil, and is dissipated throughout the bulk of the oil by agitation and by convection currents, and the speed of this heat transference will be affected by the fluidity of the oil.

Theoretically the higher the temperature of the cooling bath the slower would be the rate of heat interchange. Within limits, the lowering of the viscosity of the oil consequent upon this increased temperature more than compensates for the retarding action of the higher temperature of the bath on heat transference. Some observations showing the effect of bath temperature on the rate of cooling are given in Table II.

TABLE II.

Test-piece temperature. ° C.	Bath temperature. ° C.	Time of cooling from 800° C. (Secs.)	Bath temperature. ° C.	Time of cooling from 800° C. (Secs.)	Bath temperature. ° C.	Time of cooling from 800° C. (Secs.)
800	46	—	73	—	86	—
700	54	6·4	76	5·4	90	5·4
600	60·5	12·4	79	12·6	96	11·4
400	67	32·8	91	30·4	103	29·8
300	67·5	53·4	92·5	49·4	103	51·4
200	69	86·2	91	80	102·5	86

For example, with a bath temperature of 46° C. the temperature of the test piece fell to 600° C. in 12·4 seconds and to 200° C. in 86 seconds, whilst with a bath temperature of 85° C. the temperature fell to 600° C. in 11·4 seconds and to 200° C. in 86 seconds.

With a much greater increase in bath temperature the increased fluidity of the oil would not be sufficient to overcome the retardation of heat transference due to the high bath temperature.

The stability of the oil as regards oxidation at the high temperatures to which it is subjected during quenching is also an important consideration. Some oils, especially fatty oils, tend to break up under these high-temperature conditions, forming sludge and increasing considerably in viscosity. Mineral oils also may increase in viscosity as the result of oxidation and the loss of light fractions by volatilization. Changes in viscosity may also result from the occurrence of a certain amount of cracking. These increases in viscosity will result in the oil giving a slower quench with increasing age. The presence of lower-boiling constituents may have a deleterious effect, owing to the formation of vapour films on the surface of the metal and the consequent production of soft spots owing to the low thermal conductivity of these vapours.

The actual effects on the cooling properties of a quenching medium of its thermal properties, such as specific heat, latent heat of vaporization, thermal conductivity, are rather debatable, although they must play a very important part in the cooling.

In conclusion, it may be suggested that the use of petroleum products for quenching purposes is of considerable importance to the industry and that this subject well merits the attention of this Institution.

DISCUSSION.

Mr. W. E. Gooday remarked that the reference to the decomposition of oil during its use as a tempering or quenching medium suggested to him that these tests would have to be repeated after the oil had been in use for some time, in order to grade the oils to which the author had referred.

Another point was that those present had heard that one oil was fatty oil, and another was a spindle oil, but they had not heard what the composition of "A" oil was.

Another point was the question of fire risk. Perhaps the author would touch on that in regard to the difference, if any, between the oils referred to.

Mr. N. E. Wood said it certainly would be of interest to examine how the oils changed on ageing, after being quenched a dozen times, and see how they would stand up. That work had not as yet been carried out.

With regard to fire risk, in the tests which had been carried out there had been one experiment which had threatened a small fire, but it had easily been put out under the conditions prevailing. How it would operate in large-scale practice he could not say.

He could not state the composition of Oil "A." It was a slightly heavier oil than the spindle oil, which was 40 seconds viscosity, and Oil "A" was 50. The fatty oil was about 70.

Mr. E. A. Evans said he should have thought that the fire risk was entirely dependent on the speed at which the metal was being immersed into the oil. If it was put in quickly, obviously there was very little fire risk—or none at all; but if it was put in slowly, then there was a fire risk.

Regarding the times of quenching, he thought it would require a clever eye to operate the stop-clocks when there were such very small periods of time to measure.

Further, he would like to know if there was any evidence that the metal was any better, or any different, with those very small changes in cooling. Personally he would not have thought so.

Mr. N. E. Wood replied that, with regard to the difference in hardness which was produced in the small test piece, the rate of cooling of the small pieces must be very rapid, and it was difficult to say how they would compare with a large piece used in practice.

He had carried out some experiments with a larger test piece (just large enough to fit it comfortably into the cage), and he had found that those times would be increased about 50 per cent. It was obvious that when one was coming on to the large piece one could probably get a large time difference between the various types of oil. With the rapid cooling which some oils might give, one was bound to get a much harder steel. The difference between water- and oil-cooling was quite well known in hardening practice.

Mr. C. R. Scott Harly asked if the author could give any figures of hardness—the actual difference of hardness figures. If he could it would be much more convincing.

Mr. N. E. Wood replied that he was afraid he could not. He had not carried out any actual hardness tests. He believed that the Bureau of Standards had done some work with regard to quenching and the actual hardness produced by various types of oil.

Mr. Harold Moore remarked that he should think that the fire hazard was very closely allied to the flash-point.

In hardening in actual practice he thought it was usual to employ a bath of a certain size and to quench as much matter per day in that bath as was convenient or possible. Therefore, the maximum temperature to which that bath rose was to some extent dependent on the specific heat, so that really one wanted to know quite a lot about the effect of quenching in hot oil. If one desired to slow up the rate of cooling at the bottom end of the water curve, the best thing was to use hot water and, similarly with oil, to use hot oil. It would not affect the temperature cooling from 900° to 600° C. very much, but it would certainly affect the cooling round about 300° C. very considerably if the temperature difference was 100° C. and less if the temperature difference was due to heating by oil.

Mr. N. E. Wood said that it was the practice of some people to quench in water, and then at a certain temperature follow that up by quenching in oil from 300° or 400° C., in order to give a much slower cooling period in the last 200° or 300° C.

Colonel S. J. M. Auld asked, arising out of a previous reply of the author's, what had made Mr. Wood choose the particular size that he had chosen for his test piece. Had he been devising an apparatus for the work he would have chosen a bigger instrument altogether. The other points upon which Mr. Wood had touched, liberation of vapours, possible slight leaking, and so on, were going to be very much more magnified in a small piece than in a large. There was a good deal of quenching to be done in even small-piece works, but, generally speaking, it was a large-scale job, and a job which usually had adjunct coolers. In the particular case under discussion would not the author have got not merely the time element much better but a more generally applicable result by using a larger piece?

Mr. Wood replied that with a large piece one was not actually measuring as near to the surface temperature as possible, and he supposed it was actually the surface hardness which was of importance in most quenched jobs.

On the motion of **The President** a hearty vote of thanks was accorded to the authors for their instructive and interesting communications.

THE NATURE OF THE OCTANE SCALE.

By E. B. Evans, M.Sc., A.I.C. (Member), E. M. Dodds, M.A., B.Sc., and F. H. Garner, M.Sc., Ph.D., F.I.C. (Member).

The present tendency in connection with fuels for aviation engines is to demand higher octane numbers, and fuels have been supplied and tested experimentally with ratings of 100 octane and over. In view of this tendency, the question of extension of the octane scale above 100 becomes of definite practical importance.

It has been realized for some time past that the octane number scale is

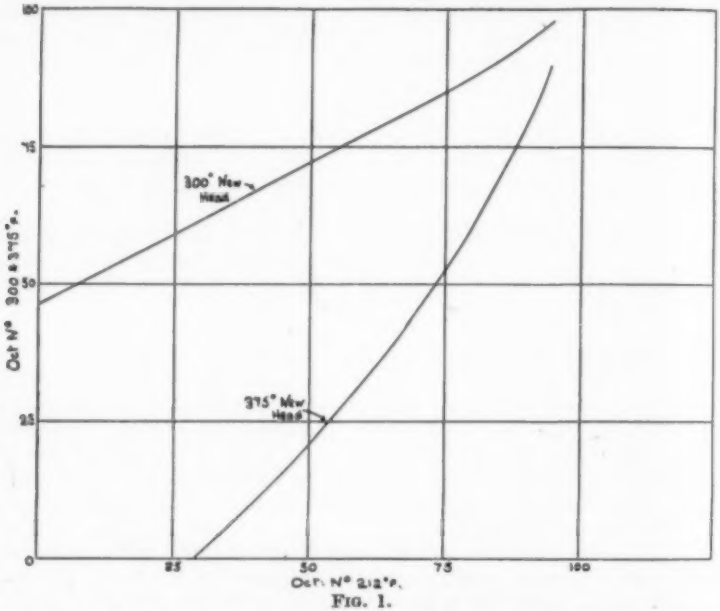

Fig. 1.

not linear, *i.e.* that a difference of one octane number at different parts of the scale does not represent the same difference of permissible maximum compression pressure or of engine performance. This is convincingly demonstrated by the reference to Fig. 1, which shows the relationships of the octane numbers of fuels required to produce equal intensities of knock under different conditions of jacket temperature and speed on the S.30 engine.* Octane numbers of fuels at 300° F. and 375° F., jacket tempera-

* See also Fig. 1, *Proc. World Petr. Congr.*, 1933, **2**, 229, where a fuller comparison is given by the S.30 engine under different engine conditions. The curves for engine speed 300 r.p.m. and 15° spark advance at jacket temperatures of 212° F., 300° F., and 375° F. show the marked effect of jacket temperatures on knock intensity.

tures on the S.30 are plotted against the octane numbers of fuels giving the same intensity of knock under 212° F. conditions. Standard knock intensity was obtained on a fuel at, say, 212° F., and then the jacket temperature and spark advance were altered to 300° F. conditions, all other engine variables being unchanged. The octane number of the fuel required to give equal knock intensity was then found. Neither of the curves in Fig. 1 is a straight line, and therefore the relations between the scales at 212° F. and 300° F. or between those at 212° F. and 375° F. are not linear; consequently at least one of the scales in each case is not linear, and in all probability neither of them will be. (Also Tables I and II.)

TABLE I.

Throttle.	Blend at 212° F. Jacket Temp./600 r.p.m./22° Spark Advance.		Blend for Equal Knock Intensity at 300° F./600 r.p.m./15° Spark Advance.	
6¼°	0% Octane	100% heptane	46% Octane	54% heptane
7½° +	30 „	70 „	62 „	38 „
9° —	50 „	50 „	72 „	28 „
10° —	70 „	30 „	82½ „	17½ „
21¼°	95 „	5 „	98 „	2 „

TABLE II.

Throttle.	Blend at 212° F. Jacket Temp./600 r.p.m./22° Spark Advance.		Blend for Equal Knock Intensity at 375° F./600 r.p.m./15° Spark Advance.	
5·6°	29·0% Octane	71% heptane	0% Octane	100% heptane
8·5°	73 „	27 „	50 „	50 „
14·75°	94½ „	5½ „	90 „	10 „

The wide differences between the octane numbers for equivalent knock will be noted particularly. Thus a fuel of 46 octane number at 300° F. will knock as badly as pure heptane at 212° F. Heptane at 375° F. knocks no worse than 29 octane at 212° F., but in this case, although the jacket temperature is increased, the speed of the engine is also greater (900 r.p.m.), and this reduces the tendency to knock.

The octane number obtained for a fuel depends on the type of engine and conditions of operation employed, and ratings are not readily converted from one set of conditions to another, even on the same engine, on account of differences in susceptibility of different fuels to temperature and other engine conditions. An interesting point in this connection is that the blending octane number curves at 212° F. and 300° F. for various series of hydrocarbons, cross at the hydrocarbon containing about eight carbon atoms.[1] Thus butyl*cyclo*pentane has a blending value on the S.30 of 0 at 212° F. and 9·5 at 300° F. These and other unexpected results are consequences of two scales of measurement being used and the relation between them being unknown. Thus, the term "Octane Number" has no meaning unless the engine and conditions of determination are rigorously specified. A large amount of experimental work by the Co-operative Research Committee of the Society of Automotive Engineers has been necessary in order

to correlate road ratings with results on the various laboratory test engines, and this work has been complicated by the lack of an absolute knock scale to which the various results could be referred.

In work [2] which has been published on blending octane numbers, it has been shown that the octane numbers of blends of paraffins are approximately linear with regard to composition, and that octane numbers of aromatic blends increase more rapidly, and of olefine blends less rapidly, than linear relationship demands. These differences emphasize the artificial nature of the octane–heptane scale, but do not encourage the belief that any other pair of substances would be more satisfactory for reference purposes.

It is not necessary to review the work on knock rating prior to the adoption of the octane–heptane scale, except to emphasize that the adoption of this scale did lead to a general simplification of the problem of knock-rating determination. The scale has, however, at the present time reached the condition of being accepted as an absolute standard of reference in the same sense as the temperature scale, and its true character may be obscured. A fundamental scale of knock tendency to which octane numbers can be referred is necessary to understand their true meaning.

In the present paper some of the work which led to the definition of such a scale is outlined, and it is believed that this leads to a truer understanding of the knock rating and of knock intensity. It is not suggested that the octane–heptane scale be abandoned, but that it be interpreted in the light of the results to be described.

The fundamental conditions of a fuel–air mixture which determine whether knocking will occur under given engine conditions are the temperature and pressure at which the mixture is compressed prior to detonation, and the temperature and pressure at which the mixture will ignite spontaneously. Pressure and temperature are, however, nearly proportional, and pressure has the advantage of being more easily measured.

In preliminary experiments the attempt was made to use the bouncing-pin as a measure of the pressure rise occurring on detonation of fuels of different octane number under the same engine conditions, but there are two objections to the use of the bouncing-pin. In the first place, a number of settings are required, using the standard C.F.R. bouncing-pin, in order to cover the range 0 to 100 octane number, and the curves obtained between octane number and knock-meter reading or gas evolution at the various settings are not continuous. Further, the motion of the bouncing-pin is proportional to the impact on the underside of the diaphragm, and this is affected not only by the rate of pressure rise after detonation, but also by the rate prior to the commencement of detonation. It is on account of this fact that the bouncing-pin gives a match between benzole and lead blends when they are not equivalent by the audibility method. Diagrams which have been obtained by the cathode-ray indicator show that the rate of pressure rise (*i.e.* of burning) prior to detonation is greater in the case of benzole than of lead blends which match according to the bouncing-pin. Consequently more of the lift of the pin is due to combustion prior to detonation in the case of the former than of the latter.

An investigation made both theoretically and practically into the use of the bouncing-pin in this way, taking into account the masses of the parts

and the spring tensions involved, led to the final abandonment of this instrument in measuring knock, in favour of a direct type of indicator.

An approximate extension of the octane scale was, however, obtained by the use of the bouncing-pin. The Society of Automotive Engineers put forward some years ago, for the purpose of rating those fuels which are better in anti-knock value than *iso*-octane, a system based on blends of *iso*-octane and C.P. benzene. Thus a fuel which matched a blend of 100 parts of *iso*-octane and 15 parts of benzene was rated at an octane number of 115. This was also adopted temporarily by the A.S.T.M. (Report of Committee D2, 1932). It is easily recognized that this extension is not continuous with the scale from 0 to 100 octane numbers, and it was subsequently abandoned. A need was, however, felt for an extension of the scale.

In this work the S.30 engine was used, but the compression pressure was raised from 195 to 230 lb./sq. in. in view of the resistance to detonation of the fuels to be tested. With the engine running at 600 r.p.m., 22° spark advance and 212° F. jacket temperature, mixtures of 95 per cent., 97 per cent. and 100 per cent. octane in heptane and of 100 parts of octane with 10 and 30 parts of benzene were matched with the aid of the bouncing-pin with blends of benzene and *cyclo*hexane, toluene, and A.2, and di-*iso*butylene and A.2. The results of these tests are given below :—

TABLE III.

Equivalent Blends at 230 lb./sq. in Compression on the S.30 engine.

Series.	Reference Blend.	Benzene and *cyclo*Hexane.		Toluene and A.2.		Di-*iso*butylene and A.2.	
1	95 Octane 5 Heptane	60·0	40·0	69·0	31·0	59·5	40·5
2	97 „ 3 „	66·5	33·5	73·0	27·0	65·5	34·5
3	100 Octane	73·5	26·5	76·5	23·5	75·2	24·8
4	100 „ 10 Benzene	74·5	25·5	77·5	22·5	78·5	21·5
5	100 „ 30 „	78·0	22·0	80·3	19·7	85·0	15·0

Considering the first three blends of toluene in A.2, knowing the octane number of each, and taking that of A.2 itself as 50·0, the blending value of toluene can be calculated in each case. Values of 115·2, 114·4 and 115·4 are thus obtained. Now, it is known that the concentration curve of toluene in A.2 is *practically* a straight line up to about 100 octane number. The value for the blending octane number is constant with a value of 115·0 at concentrations of 69·0–76·5 per cent. toluene, so that one may confidently assume that the blending value will not alter appreciably up to concentrations of 80 per cent. toluene. The octane numbers of the toluene/A.2 blends, and consequently of the *iso*-octane/benzene blends in Series (4) and (5), can therefore be calculated.

Hence it is found that a blend of 100 parts of *iso*-octane and 10 parts of benzene has an octane number of 100·4 on the extended scale continuous, with the 0 to 100 scale obtained by means of mixtures of *iso*-octane and *n*-heptane, as against the nominal rating of 110 by the method originally suggested by the S.A.E. Similarly, 100 parts of octane and 30 of benzene has an octane number of 102·2.

Treating the di-*iso*butylene data similarly, we get, from Series 1, 2 and 3,

the blending values of 125·5, 121·7 and 116·5 for di*iso*butylene in A.2. These values are decreasing too rapidly to permit of extrapolation, a result which is not surprising in view of the rapid flattening of the concentration–octane number curve for di*iso*butylene.

Considering the first three blends of benzene and *cyclo*hexane, three equations can be constructed for the octane numbers, each involving, as

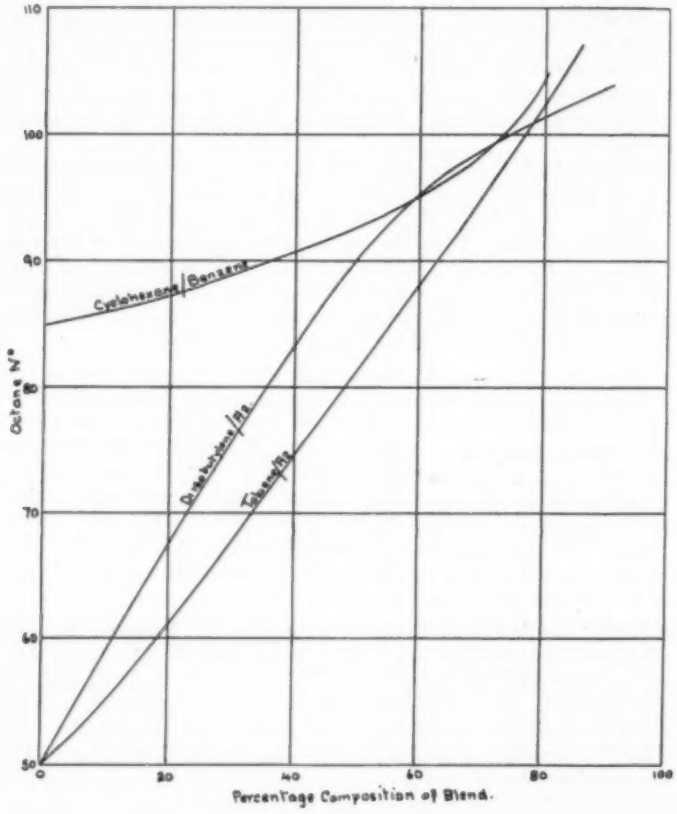

FIG. 2.
S.30, 212° F.

the two unknowns, the blending values of benzene and *cyclo*hexane when mixed together. Solving the first and second and second and third equations together, we get for the blending values:

Benzene, 108·3. *cyclo*Hexane, 75·0 (from (1) & (2))
Benzene, 114·4. *cyclo*Hexane, 68·5 (from (2) & (3))

These values are not as nearly constant as might be desired, but using he average blending va lues of 109·9 and 71·8, the values of the blends of

octane with ten and thirty parts of benzene are calculated as 100·0 and 101·5, respectively. These values are fairly close to those obtained from the toluene blends (100·4 and 102·2). The values from the latter are likely to be more accurate, however, on account of the almost linear concentration curve.

The above results, which were obtained with the bouncing-pin, are plotted in Fig. 2, together with the remainder of the curves from 100 per cent. of *cyclo*hexane or A.2.

During the course of this work, the cathode-ray indicator [3,4] as described elsewhere was developed, and this allowed, for the first time, the pressure changes during the engine cycle to be followed accurately, and

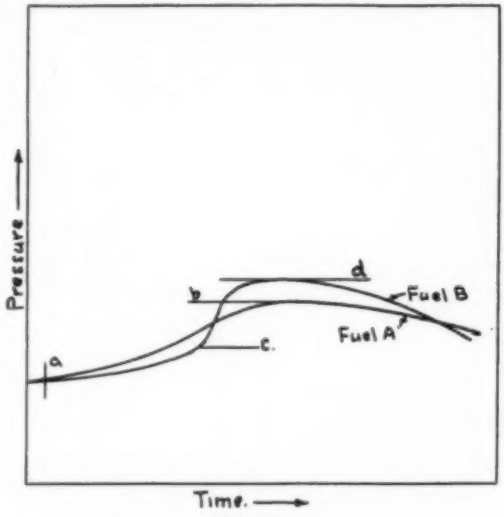

FIG. 3.

differentiation to be made between pressure rises before and after the commencement of detonation.

From the indicator diagrams the maximum cylinder pressures for which combustion is just non-detonating with given fuels and engine settings, the pressures at which detonation begins and the maximum pressures obtained during detonation can be obtained *inter alia*.

Fig. 4 indicates the type of curve obtained by plotting the maximum pressures for combustion without detonation ("quiescent combustion") against octane number. If P_1 and P_2 represent the quiescent combustion pressures for fuels of, say, 60 and 90 octane number, then if the 60 octane number fuel is burnt in the engine at a setting for which the 90 octane number is just non-detonating, the pressure rise on detonation of the 60 octane fuel will be proportional to $P_2 - P_1$. The nature of the proportionality will be discussed later, but it is clearly shown by the indicator diagrams that the enormous pressure rises formerly believed to occur on

detonation do not happen, but are illusions due to the inertia of moving parts of the indicators previously employed. Consideration of Fig. 4 makes it obvious why a change of one octane number in the value of a fuel at, say, about 90 octane produces a far greater effect, and is more easily detected, than a similar change at, say, 20 octane. The actual "quiescent combustion pressure" changes much more rapidly for each octane number improvement at the upper end of the scale. The use of the pressure scale has the advantage that the experimental accuracy is the same over the whole range; a difference of 1 lb. pressure has the same meaning throughout the scale, whereas a difference of one octane number has not.

The diagram (Fig. 3) illustrates the effect of running a lower-octane-

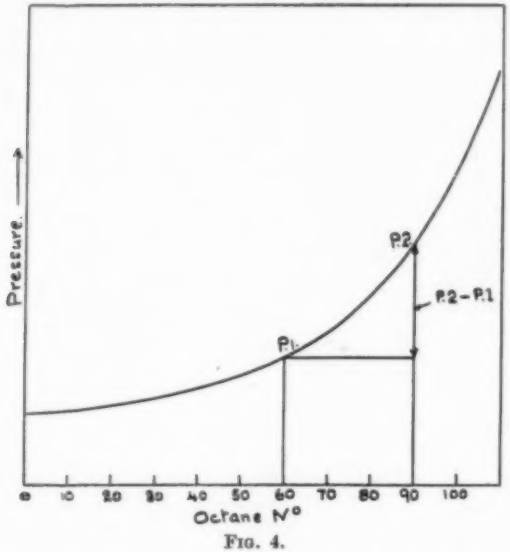

FIG. 4.

number fuel at an engine setting for which a better fuel will just not detonate, the curves representing the expanded indicator diagrams.[3,4] The spark passes at *a*, and *b* represents the quiescent combustion pressure on the fuel *A*. On the lower octane number fuel *B*, detonation commences at *C* and the peak pressure obtained is *d*, so that the pressure rise due to detonation is *d*—*c*.

Although the new indicator gives a diagram the ordinates of which are proportional to pressure, it was considered that a gauge which could be fitted to the engine for recording peak pressure accurately would be very advantageous, since the size of the pressure–time diagram obtained on the screen is a function of the cathode-ray tube voltages. The gauge is on the lines of the C.F.R. compression gauge, but is designed to withstand explosion pressure, and has proved very satisfactory for this purpose. Such a gauge is capable of recording peak pressures accurately even under conditions of severe detonation.[3]

By means of this gauge, experimental results were obtained which are shown in full in Figs. 5 and 7.

Series 30 *Engine.*—Fig. 5 shows results on the S.30 engine at 212° and 300° F. jacket temperature, speed and spark advance being kept standard and the throttle opening varied to obtain the maximum combustion

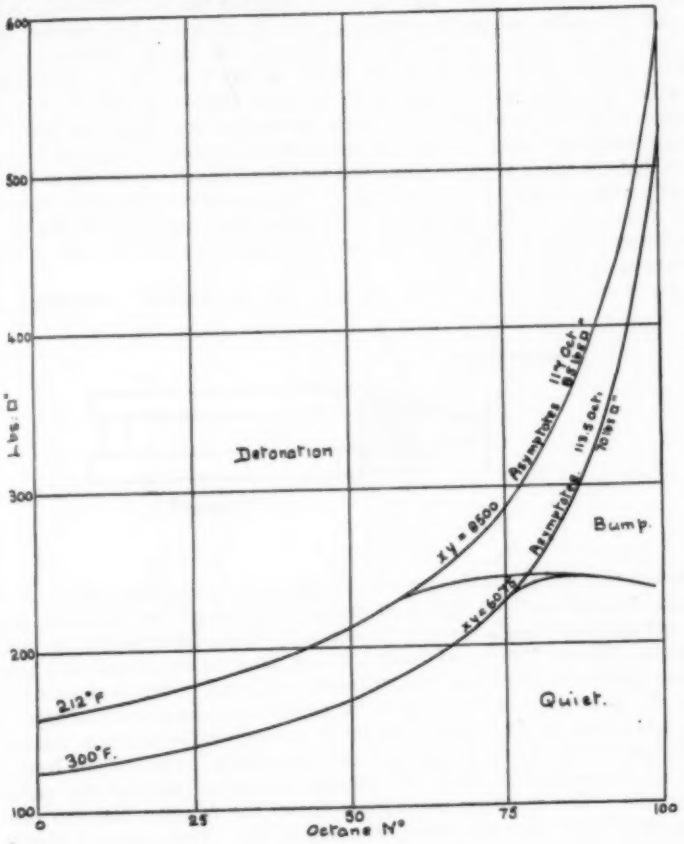

FIG. 5.
S.30.

pressure at which detonation just did not occur, this last being determined as described later. The curves are found to be hyperbolic, the equations and asymptotes being as follows :—

212° F. $XY = 8500$, with asymptotes at 117 octane number and 85 lb./sq. in.

300° F. $XY = 6075$, with asymptotes at 113·5 octane number and 70 lb./sq. in.

Extension of the octane scale beyond 100 is thus obtained simply by extrapolating the curve beyond 100 octane number, according to the equation, and reading off the corresponding maximum quiet combustion pressure.

It will be observed that over the range 0–100 octane numbers the maximum pressure which a given octane number fuel will withstand is less at 300° F. jacket temperature than at 212° F., as would be expected from the higher temperature employed. No fuel will knock, however, up to 85 lb./sq. in. at 212° F. or up to 70 lb. at 300°; a fuel of 113·5 octane number or above will not knock in the S.30 engine at 300° F., but 117 octane or above is required to render detonation impossible at the lower jacket temperature of 212° F. This apparent anomaly is explained by the fact that the spark advance employed for the standard conditions at 212° F. is 22°, whilst at 300° F. it is only 15°. The equation of the curve obtained and the values of the asymptotes are dependent not only on the actual engine employed, but also on the speed and spark advance, as well as on the jacket temperature.

An offshoot from the 212° F. curve in Fig. 5 is marked " bumping," and

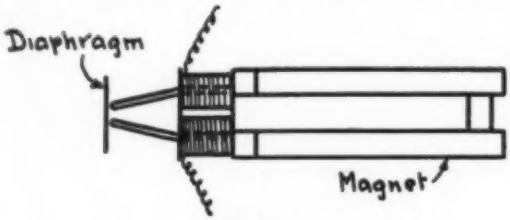

FIG. 6.

between this and the main curve is the region of " rough running." At the " 212° conditions " on the S.30 engine, this condition starts at about 60 octane, but rough running is naturally dependent mainly on engine design. The occurrence of bumping was detected by means of a microphone device screwed into the cylinder head, and which is illustrated in Fig. 6. It is of the electromagnetic type, and the voltage output from it is applied to the grid of a high-frequency pentode valve which is resistance coupled to the source of the high-tension supply. The output from the anode of this valve is fed to the vertical deflecting plates of the cathode-ray tube. The resulting oscillogram shows the relation between rate of change of pressure and time or crank angle. The bumping region is differentiated from that of quiet combustion by departure of the oscillogram from a smooth curve.

C.F.R. Engine.—Results on the C.F.R. engine under motor method conditions are shown in Fig. 7.

The curve for maximum quiet combustion pressure has the equation $XY = 8900$, with asymptotes at 138 octane number and 165 lb./sq. in. Rough running starts at about 75 octane number in this case. The other curve represents peak pressures at the standard intensity of knock for " motor method " operation. The equation in this case is $XY = 9700$, with asymptotes at 129·5 octane number and 200 lb./sq. in.

These two curves are roughly parallel (they are, in fact, two members of a family of hyperbolas), but it will be seen that the difference in peak pressure for quiet combustion and for standard intensity of knock is from 46 lb. at 0 octane to 130 lb. at 100 octane. (Standard intensity of knock was obtained by setting the engine to give mid-scale reading as laid down in the C.F.R. motor method instructions. The intensity of detonation as shown by the indicator was then determined, and the same amount of pressure rise on detonation maintained throughout the experiments. It is not

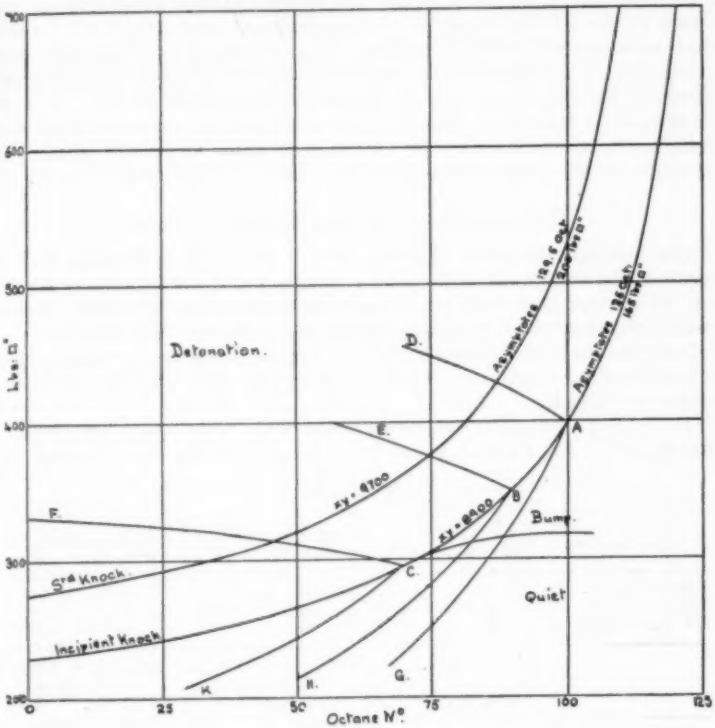

FIG. 7.

C.F.R. MOTOR.

accurate to assume that mid-scale knock-meter reading indicates constant degree of knock throughout the range 0 to 100 octane.) This is interesting in view of recent work, which has shown that, in order to get agreement between octane ratings in different laboratories, it is necessary to standardize very carefully the degree of knock obtained.

In Fig. 7 there are a number of curves offshooting from the main quiescent combustion curve, and which are obtained by the use of the cathode-ray indicator and of the pressure gauge. The points *A*, *B* and *C* correspond to the quiescent combustion pressures of fuels with octane numbers of 100, 90

and 70, respectively. The curves *AD*, *BE* and *CF* represent the peak pressures obtained with fuels of progressively lower octane number at the engine settings corresponding to the points *A*, *B* and *C* on the main curve. The curves *AG*, *BH* and *CK* show the pressures at which detonation begins on fuels of various octane numbers at these settings, and consequently vertical distances between *AD* and *AG*, *BE* and *BH* and *CF* and *CK* are the intensities of detonation under these conditions. It will be observed that the detonation pressures are always greater than the differences in the quiet combustion pressures for the fuel tested and that which will just not knock at the setting employed. Considering *AC* and *AG*, it will be seen that the compression ratio is constant along *AG*, and greater than for points along *AC*. Consequently the cycle temperature is higher along *AG*, and therefore the pressure at which detonation commences is less. A larger proportion of the charge therefore detonates as the commencing pressure gets lower, and consequently the final pressure is greater also. This accounts for the shape of the curves *AD*, *AG*; *BE*, *BH*; and *CF*, *CK*.

Correlation of Octane Number Scales.

The methods described therefore give a means of evaluating fuels in terms of the maximum combustion pressures which can be employed without detonation occurring, on a standard engine running under standard conditions of speed, temperature and spark advance. The pressure scale is independent of the idiosyncrasies of any pair of reference substances, but it may readily be correlated with the octane–heptane scale on the particular engine employed.

In Table IV are given octane numbers of six fuels, which are blends of Reference Fuel C.7 and A.3 and C.7 + lead, from the curves issued with

Table IV.

Fuel Engine.	A.3. Oct. No.	A.3. P.	40% A.3/60% C.7 Oct. No.	40% A.3/60% C.7 P.	20% A.3/80% C.7 Oct. No.	20% A.3/80% C.7 P.
S.30 at 212° F.	42	198	55	222	68	260
S.30 at 300	41½	156	54½	174	67½	202
C.F.R. Engine	44	260	56½	274	69	295
	C.7. Oct. No.	C.7. P.	C.7+1 c.c. TEL per U.S. gallon. Oct. No.	C.7+1 c.c. TEL per U.S. gallon. P.	C.7+2 c.c. TEL per U.S. gallon. Oct. No.	C.7+2 c.c. TEL per U.S. gallon. P.
S.30 at 212° F.	74½	285	83½	338	87	370
S.30 at 300	74	224	84·7	280	89	318
C.F.R. Engine	75	306	83½	328	86½	338

P = Maximum quiet combustion pressure in lb./sq. in.

these fuels by the Standard Development Co. and Ethyl Gasoline Corporation, together with the combustion pressures for incipient knock on the S.30 engine at 212° F. and 300° F. and on the C.F.R. engine as obtained from Figs. 5 and 7. These results are plotted on Fig. 8, which shows C.F.R. and S.30 at 212° F. results against those on the S.30 at 300° F. Smooth curves are obtained indicating that satisfactory correlation can be achieved between different engines on a pressure basis.

Thus it is seen that the method of plotting on a pressure basis eliminates the complicated effects of the varying temperature susceptibilities of fuels compared with octane and heptane.

Extension of the Octane Number Scale.

The occurrence and degree of knocking may be obtained directly from diagrams on the cathode-ray indicator or a pressure gauge in conjunction

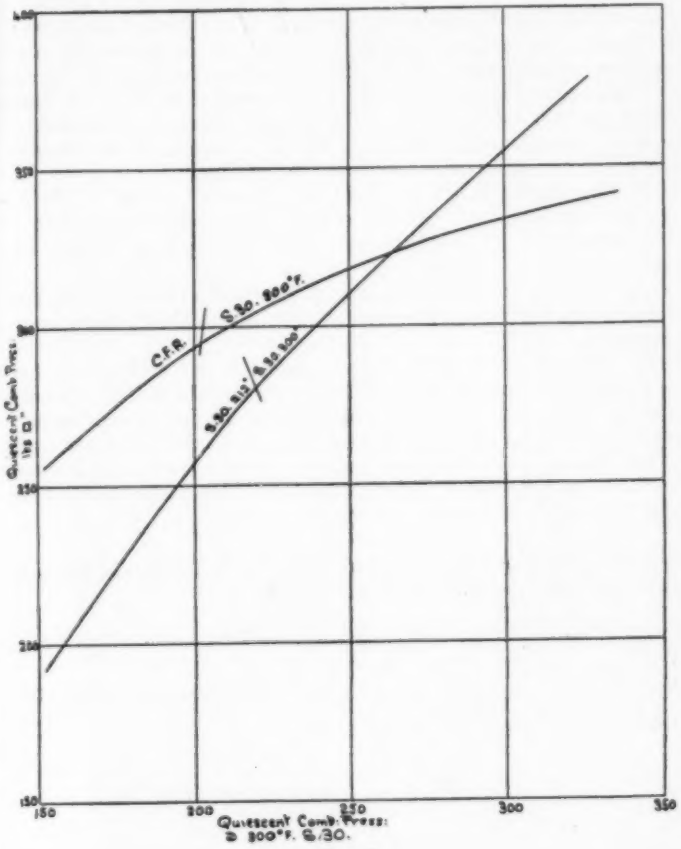

Fig. 8.

with the ear or a microphone may be employed. The inherent disadvantages of the bouncing-pin may thus be avoided, together with the present unsatisfactory methods of obtaining standard knock intensity.

The pressure scale also gives a convenient method of extending knock-rating measurements to fuels of higher anti-knock value than *iso*-octane,

and of determining octane numbers in the range 85–100 where difficulties are encountered with the C.F.R. motor method.

In practice, the following procedure may be adopted, using the curve given in Fig. 7 for the C.F.R. engine for incipient knock as a basis. It will be understood that Fig. 7 applies to one particular C.F.R. engine only, and although the curve for other engines will not differ very greatly from the curve shown, it is desirable that similar curves be constructed (from at least ten points) as basic calibration curves for the particular C.F.R. engine employed.

The method which is proposed involves two separate operations: (1) determination of incipient knock either by ear or preferably using a microphone or temperature plug. This operation involves in the case of the C.F.R. engines adjustment of the compression ratio under standard conditions so that a constant, very slight degree of knock is obtained, which is regarded as incipient detonation; (2) determination of the pressure by means of the procedure described earlier in the paper.

The octane number is now read off from the curve (as Fig. 7). By means of the pressure gauge the pressure can be read to within less than 5 lb., which corresponds to a maximum difference of 1 octane number at 100 octane number.

Octane numbers both in the range 85–100 and above 100 can thus be determined by obtaining the pressure of incipient knock under standard conditions.

It is generally felt that the C.F.R. engine is not satisfactory for the determination of octane numbers of the above ranges and alternative engines are being considered. Methods are proposed in the present paper (see particularly Fig. 8) which enable a comparison of octane number scales on different engines to be obtained, and thus even if the engine is changed, the octane number scale as obtained for the C.F.R. motor method can be retained as a standard scale of reference.

In conclusion, the authors wish to thank Mr. C. H. Sprake for valuable assistance in the experimental work involved.

References.

[1] Garner and Evans, *J.I.P.T.*, 1932, **18**, 751.
[2] Garner, Evans, Sprake and Broom, *Proc. World Petr. Congr.*, 1933, **2**, 170.
[3] *Engineering*, 1935, **140**, 183.
[4] *Automobile Engineer*, 1935, **25**, 323.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

THE Fifth Annual Dinner of the Trinidad Branch of the Institution of Petroleum Technologists was held at the Queen's Park Hotel, Port of Spain, on October 26th, 1935. Commander H. V. Lavington, R.N., was in the Chair, the guest of honour being His Excellency the Governor, Sir Claud Hollis, G.C.M.G., C.B.E., who was attended by Captain S. H. Batty-Smith, A.D.C.

"The Institution of Petroleum Technologists."

His Excellency the Governor, in proposing the toast of the Institution, referred to the importance to Trinidad of the oil industry, stating that in 1934 the value of the exports of petroleum and petroleum products was nearly three million pounds sterling, or 63 per cent. of the value of the total exports for the Colony.

The new Oil Mining Regulations issued in December 1934 were a great improvement on those previously in force. They had met with general approval except on the question of size of areas to be leased, regarding which there was a little difference of opinion.

Although some people might regret some of the innovations caused by the use of oil, and deplore the toll of life and limb on the roads and the destruction of amenities of the countryside, the world was greatly the gainer for the discovery and exploitation of petroleum.

Most of the modern wars had been attributed to the search and fight for oil, but the work sponsored by the Institution offered one of the greatest fields for fostering friendly international relations. It had no national boundaries, and brought together individuals of different countries, who were bound by a common intellectual interest.

Commander H. V. Lavington, in responding, said he had much pleasure in reading the following telegram, which had been received from the parent Institution :—

"Greetings from Institution Council and all good wishes for successful evening. Cadman, President."

The present year was an important one in the history of the Institution of Petroleum Technologists, and he was sure all would agree that it was a particularly happy coincidence for the Trinidad Branch that the President of the Institution this year was Sir John Cadman. His name would always be associated with those wise measures which helped to foster the Trinidad oil industry in its infancy.

Looking back over the period since the foundation of the Institution, he

thought it could be said, without undue conceit, that the scientific results achieved by the Institution and by its members during that time had been of great practical benefit to the Industry and to the nation. He assured His Excellency that close attention was being paid by the members of the Trinidad Branch to those scientific measures which were necessary in order that the Colony's petroleum resources should be exploited in the most efficient manner.

Each year saw a closer collaboration between science and industry and the displacement of rule-of-thumb methods in all branches of production, but the economic problems of the world seemed as far as ever from reaching a permanent solution.

Individuals and nations were more than ever realizing the necessity for collective action, and at present the attempt which was being made to solve a political problem by these methods was being anxiously watched.

He thought that the lessons to be learnt would enable a new International Economic Conference to be called, which would succeed in reconciling the divergent views and needs of the different nations and would attain a measure of success which would gradually restore stability to the world.

He expressed his thanks to the Branch Committee for all the help they had so willingly given him throughout the year, and in particular to Mr. Wallace Reid, the Honorary Secretary, on whom fell the more arduous duties in connection with the Branch. They all regretted the decision of Mr. Hugh Scott to retire from the Branch Chairmanship at the end of last year, as it was largely due to his guiding hand that they were able to record continued progress.

"The Industries of Trinidad."

Colonel H. C. B. Hickling, in proposing this toast, referred to the difficulty of a planned economy under present economic conditions. Producers might look longingly to Russia, where rapidly increasing production was still unable to keep pace with consumption. In a loosely-knit Empire, where each unit controlled its own destiny according to its state of development, central control was out of the question.

Mr. A. Emlyn, in reply, congratulated the oil industry on furnishing a large proportion of the Island's exports.

"Our Guests."

Mr. L. A. Bushe proposed the toast of "Our Guests," which was replied to by the **Right Reverend A. H. Anstey, M.A., D.D.**, Lord Bishop of Trinidad.

WORLD PETROLEUM CONGRESS.

THE audited Statement of Accounts of the World Petroleum Congress held in London in July 1933 is presented herewith.

The Council of the Institution of Petroleum Technologists again wish to express their appreciation of the generous financial support received as contributions to the Guarantee Fund. Without the aid of these contributions an undertaking of the magnitude of the Congress would not have been possible.

The support and assistance which the organizers of the Congress received from H.M. Government, the Governing Board of the Imperial College of Science and Technology, the Board of Governors of the Imperial Institute and numerous other public and private organizations and individuals have already been acknowledged by the President of the Congress (Mr. T. Dewhurst) in the Preface to the published *Proceedings*. The Council of the Institution take this opportunity of endorsing the sentiments expressed in that Preface.

The gratifying reception which has been accorded throughout the world to the *Proceedings* establishes the World Petroleum Congress of 1933 as a landmark in the development of petroleum technology.

At the final Plenary Session on 25th July, 1933, it was resolved that the task of arranging the meeting place of the next Congress, to be held in 1936, be entrusted to the Institution of Petroleum Technologists. Towards the end of 1934 an endeavour was made to arrange for the Congress to be held in the United States in 1936. Unfortunately, owing to a number of circumstances, the negotiations were not successful.

A Referendum was taken in July 1935 of the views of the members of the first Congress, seeking their approval of a modification of the abovementioned resolution, and authorizing the Congress Executive Committee to postpone the Congress from 1936. The result of the referendum was practically unanimous in favour of postponement.

An invitation was received from the Association Française des Techniciens du Pétrole, of which society Colonel Louis Pineau is Honorary President and M. Charles Bihoreau is President, to hold the next Congress in Paris in June or July 1937. This date coincides with that of the Exposition Internationale, which is being organized by the French Government.

The Council of the Institution of Petroleum Technologists were pleased to accept this invitation. The task of organizing the second World Petroleum Congress will devolve on the French Association, but the Council of the Institution will remain in close touch with arrangements.

JOHN CADMAN, *President*,
The Institution of Petroleum Technologists.

November, 1935.

THE WORLD PETROLEUM

RECEIPTS AND PAYMENTS ACCOUNTS FOR THE PERIOD

1. CONGRESS ACCOUNT.

RECEIPTS.

	£ s. d.	£ s. d.
Contributions to Guarantee Fund	1253 18 0	
Donations for Special Purposes	250 0 0	
		1503 18 0
Membership Fees		543 10 0
Receipts on Account of :—		
Banquet	131 2 6	
Excursions	247 16 6	
		378 19 0
Interest Received on Deposit Account		2 6 9
		£2428 13 9

2. PUBLICATIONS ACCOUNT.

	£ s. d.
Sales of Preprints	590 6 3
Sales of Proceedings	1794 18 11
Balance being Excess of Payments over Receipts	551 16 1
	£2937 1 3

SUMMARY.

	£ s. d.	£ s. d.
Excess of Receipts over Payments on Congress Account	659 19 3	
Less : Excess of Payments over Receipts on Publications Account	551 16 1	
		£108 3 2

We report that we have examined the foregoing Statement of Receipts and Payments with the Books and Vouchers of the Congress and find it to be in accordance therewith.

Price, Waterhouse & Co.

3, Frederick's Place,
Old Jewry, London, E.C. 2.
7th August, 1935.

CONGRESS, 1933.

FROM 9TH DECEMBER, 1932, TO 20TH JULY, 1935, INCLUSIVE.

PAYMENTS.

	£	s.	d.
Expenses of Banquet	232	5	4
Excursions and Visits	230	14	4
Delegates' Dinner	74	17	1
Hire of Meeting Halls	86	6	1
Printing and Stationery	225	13	2
Postage	105	4	2
Expenses of Reception	82	16	10
Salaries and Honoraria	564	16	8
Cost of Badges	56	19	3
Sundry Expenses	109	1	7
Balance, being Excess of Receipts over Payments	659	19	3
	£2428	13	9

	£	s.	d.
Cost of Preprints	566	7	6
Cost of Proceedings	2307	3	7
Postage of Proceedings	63	10	2
	£2937	1	3

	£	s.	d.	£	s.	d.
Cash at Bank and in Hand at 20th July, 1935:—						
At Bank	104	8	3			
In Hand	3	14	11			
				£108	3	2

J. Kewley, Chairman, Congress Executive Committee.
S. J. Astbury, George Sell } Joint Secretaries.

THE WORLD PETROLEUM CONGRESS, 1933.

CONTRIBUTIONS TO GUARANTEE FUND.

	£	s.	d.
Anglo-American Oil Co., Ltd.	100	0	0
Anglo-Iranian Oil Co., Ltd.	100	0	0
Asiatic Petroleum Co., Ltd.	100	0	0
Burmah Oil Co., Ltd.	100	0	0
Eagle Oil & Shipping Co., Ltd.	100	0	0
Apex (Trinidad) Oilfields, Ltd.	50	0	0
Imperial Chemical Industries, Ltd.	50	0	0
Lobitos Oilfields, Ltd.	50	0	0
National Benzole Co., Ltd.	50	0	0
Russian Oil Products, Ltd.	50	0	0
Trinidad Leaseholds, Ltd.	50	0	0
Vacuum Oil Co., Ltd.	50	0	0
C. C. Wakefield & Co., Ltd.	50	0	0
British Controlled Oilfields, Ltd.	30	0	0
Agwi Petroleum Corpn., Ltd.	26	5	0
London Passenger Transport Board	26	5	0
Babcock & Wilcox, Ltd.	25	0	0
T. C. J. Burgess, Esq.	25	0	0
London & Thames Haven Oil Wharves, Ltd.	25	0	0
Prices Patent Candle Co., Ltd.	25	0	0
Stewart & Lloyds, Ltd.	25	0	0
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Bristol Aeroplane Co., Ltd.	10	10	0
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Kern River Oilfields of California, Ltd.	10	10	0
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A. F. Craig & Co., Ltd.	10	0	0
Dunlop Rubber Co., Ltd.	10	0	0
Foster Wheeler, Ltd.	10	0	0
Motherwell Bridge & Engineering Co., Ltd.	10	0	0
National Gas & Oil Engine Co., Ltd.	10	0	0
Ruston & Hornsby, Ltd.	10	0	0
John G. Stein & Co., Ltd.	10	0	0
Cochran & Co., Ltd.	5	0	0
Anonymous	3	3	0
W. B. Dick & Co., Ltd.	3	3	0
	£1253	18	0

DONATIONS FOR SPECIAL PURPOSES.

Viscount Bearsted	50	0	0
Viscount Wakefield	50	0	0
Sir John Cadman	50	0	0
T. Dewhurst, Esq.	50	0	0
J. B. Aug. Kessler, Esq.	50	0	0
	£1503	18	0

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